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USE OF INFORMATION AND
MANUFACTURING TECHNOLOGIES
AS TURNAROUND STRATEGIES

Joseph G. San Miguel

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To compete successfully in the global environment, companies have been encouraged to implement information technology as well as other technologies. The premise is that better information will result and that this will lead to improved decision making. This research examines the planning and control of operations in three organizations. Each of these organizations in the computer industry faced serious pressure to improve or else. Operating managers responded by implementing networked computer systems, total quality management, just-in-time, electronic data interchange, and other information systems. Significant improvements in design, quality, manufacturing cycle times, inventory control, space utilization, and delivery were reported.

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USE OF INFORMATION AND MANUFACTURING TECHNOLOGIES AS TURNAROUND STRATEGIES

by

Joseph G. San Miguel
Naval Postgraduate School
Monterey, CA 93943
(408) 656-2187

Executive Summary

To compete successfully in the global environment, companies have been encouraged to implement information technology as well as other technologies. The premise is that better information will result and that this will lead to improved decision making. This research examines the planning and control of operations in three organizations. Each of these organizations in the computer industry faced serious pressure to improve or else. Operating managers responded by implementing networked computer systems, total quality management, just-in-time, electronic data interchange, and other information systems. Significant improvements in design, quality, manufacturing cycle times, inventory control, space utilization, and delivery were reported.

Key Words: information technology, planning and control, information systems, just-in-time, networks.

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USE OF INFORMATION AND MANUFACTURING TECHNOLOGIES AS TURNAROUND STRATEGIES

The theories and practices in management information systems that served companies in the past must undergo examination and change to meet the needs of the 1990s and beyond the year 2000. In addition to increasing global competitive pressure, new views of the worker and significant improvements in technology have brought about new challenges to the design and implementation of information systems in our largest organizations. Decision making and information processing in large, complex organizations are changing to meet these challenges. Three case studies will be presented that illustrate the impact of new technology and information on improvements in performance.

Traditional Management Information Systems

Numerous concepts and theories have been advanced for explaining how large, complex organizations should plan and control their operations through information (Arrow, 1956; Anthony, 1965 & 1988). "Organizational control" in Arrow's hypothesized framework is concerned with how the organization "can best keep its members in step with each other to maximize the firm's objective function" (p. 398). In his approach, "operating rules" instruct the firm's members on how to act, and "enforcement rules" are necessary to persuade or compel the firm's members to take actions that are in accordance with the firm's operating rules. Thus, Arrow's approach is based on rules or policies that must be established within the organization. In a subsequent work, Arrow

(1974) pointed out that an organization really consists of a collection of human decision makers whose information storage and processing skills are limited. Viewed this way the organization has limitations as to the information collected, sorted, processed, and retrieved. As we will see, technology and specialization are moving the boundaries of information and decision making, thus enabling new approaches to information processing.

In contrast to Arrow, Anthony (1965) recommended a more pragmatic framework for information systems that is based on three rough categories of management decision making processes:

> Strategic planning is the process of deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources.
> Management control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives.
> Operations control is the process of assuring that specific tasks are carried out effectively and efficiently.

Subsequently, Anthony (1988) made some refinements to his framework. These have not altered his basic approach. Implicit in his framework is the gathering and upflow and downflow of information, the fuel for decisions at all levels of management. Information may be from internal or external sources, quantitative or qualitative, financial or non-financial, and historical or futuristic.

New Directions

The traditional approaches to management information systems have led to much research and practical developments in past years (Kirkpatrick, 1991; Porter & Millar, 1985; Scott Morton, 1991). However, the organizations that are the subjects of these tools are evolving in unexpected directions. As Zuboff (1988) discovered, workers and managers in modern technology-driven organizations are vital to the successful implementation of the technologies. Today, there are new ways of dealing with suppliers and customers. Just-in-time (JIT) inventory management has caused unprecedented information sharing between buyers and sellers (Handy, 1989). Electronic data interchange (EDI) has eliminated much of the paperwork involved in purchasing and payments (Sokol, 1989). Previous hard nosed competitors are forming joint ventures in certain product or process development areas that have vast strategic implications (e.g., IBM and Apple, and Siemens with IBM).

Within the firm, the "production" processes are being evaluated to give the individual new decision making authority and the information for those decisions (Hammer, 1990; Porter & Millar, 1985). As used here, "production" refers to any knowledge process and is not restricted to the physical manufacture of a product. An engineer is certainly a knowledge user who produces new ideas and concepts. A purchasing employee likewise uses a knowledge base to produce a service or procure materials and parts. The new approach focuses on information processing requirements of all employees' production processes. In addition, the use of Total Quality Management (Deming, 1982) emphasizes the role in quality control that each and every employee plays in the production of goods and services for a customer, whether that customer is internal or external to the organization.

Accompanying this emphasis on the knowledge worker is a technological revolution. Computer workstations are assisting engineers with Computer Aided Design (CAD) software. Teams of knowledge workers from design, engineering, production, and marketing are linked through networks of computers. Sales representatives are using hand held computers to help formulate customers' inventory purchases, labels, and invoices. Customers can enter orders through electronic data interchange into the suppliers' information system (Sokol, 1989).

Role of Technology

The commercial and business press have heralded the onset of new technology or applications of manufacturing and information technology. Countless articles have been written touting the improvements in products and processes that are due to technology. Another type of technology is that of "management technology" such as Total Quality Management and Just-in-Time inventory management mentioned above. A partial list of these technological developments is given in Exhibit 1. Most modern organizations have studied or implemented some of the listed technologies. A reading of the literature would lead one to believe that implementations have been positive with significant rewards for managers and the stockholders.

This research was initiated by a survey of large companies based in the San Francisco Bay Area in 1990. The purpose was to locate examples of Flexible Manufacturing Systems (FMS). Although some highly automated manufacturing operations were discovered, no FMS were found (Sheridan, 1989). The other technologies listed in Exhibit 1 were being implemented in varying degrees, but the most dramatic efforts were found in organizations that were under serious top management or owner pressure to improve operations or be closed. Therefore, the research turned to these organizations that were using information and other technologies as part of their of turnaround strategies.

To demonstrate the impact of new technology on management information systems in these turnaround situations, three companies in the computer industry were identified. Each of these companies had implemented various combinations of the technologies listed in Exhibit 1 in an attempt to improve operations and competitive position. Total Quality Management (or continuous improvement) and Just-in-Time were implemented in all cases. Computer integrated manufacturing was also present in all cases. The time period for identification of the need for changes started in 1985 or 1986. The latest complete year of data was 1990.

<u>Field Research at Three Companies</u>

Following interviews with company management and employees, three companies in the computer industry were selected within the San Francisco Bay Area. Although companies in other industries were available, information technology was more familiar to managers in the computer industry. Confidentiality of the companies and data collected were conditions of the research. The selected computer companies represent different sizes of operations. They are described as follows:

Company A: A manufacturing division of a very large, worldwide company
Company B: A manufacturing plant of a large company
Company C: A small privately held company

The criteria for selecting these companies were as follows:

Technology intensive with high turnaround pressure from headquarters and/or owners

Serious problems with competitors and market position
Need to improve quality and product delivery
Heavy people involvement clear management leadership
Emphasis on education of employees and team building
Relatively insignificant capital investment in technology
Evidence of top management commitment to change, quality, and lower costs

While the implementation of changes in technology started during the mid-1980s, some efforts at TQM and JIT may have started earlier but failed to significantly change operations. It is important to understand that in each case there were no major capital proposals or investments. Rather, operating managers familiar with day to day needs initiated changes utilizing existing manufacturing and computer equipment. In some cases, small PC based computers were purchased. These were not very large investments, avoiding the corporate justification process (Noble, 1989). In summary, local operating managers were in charge.

A short description of each company follows:

Company A: The largest organization was the manufacturing division of Company A. The manufacturing technology for this and other product divisions are networked. This division has a specific responsibility for product development and manufacture. Exhibit 2 provides some of the background data of this division. This organization implemented JIT, TQM, and CAD/CAM, but made very little investments in computer hardware. The operating managers assembled teams to examine portions of each operation.

Company B: The second largest organization was a large plant of a large corporation. The operating data for this organization are given in Exhibit 3. /While not as large as Company A, this company was under serious cost reduction pressure. Like Company A is was a publicly held company.

Company C: This was the smallest of the organizations and it was also privately held by a group of investors and owner-managers. It was an innovator in setting the industry standard for PC Compatible Computers in the early 1980s. The founder and majority owner relinquished control to a new management team. The vice president of operations recently joined the company from another company in related business. The background data on this organization is presented in Exhibit 4.

Results From Changes and Technology

Following three to four years of management and employee education and training, team building, and physical changes in facilities, each company was able to document significant improvements in operations. As mentioned previously, in each case the operating managers were the major drivers of the changes. The finance and management information systems personnel were only involved at the end of the design process. In the case of Company B, the operations people designed the new systems and invited the MIS personnel to implement the system. After the new systems were up and running, the operating managers took ownership of the MIS and assumed responsibility for future MIS changes. This illustrates "end-user" computing in which the user exercises authority over the design and implementation of information technology and systems (Henderson & Treacy, 1986).

There were many common results at all three companies as a result of the implementation of changes in different technologies. The results in terms of reductions in resources, improved quality, and other attributes are summarized in Exhibit 5. Not all companies gathered performance measures in each attribute. For example, only Company C tracked "On-Time Shipments."

Discussion of the Findings

Reductions in personnel, inventories, and facilities space generally lead to real cost savings. For example, by decreasing the number of suppliers and purchased parts, purchasing department personnel and costs were lowered and expediters were eliminated. In the case of Company C, there had been a real shortage of storage and manufacturing space. As a result of space saving, a search for new space was terminated and administrative and operation activities were subsequently consolidated. The reductions in personnel were difficult but in most cases normal attrition was sufficient to lower the number of employees. Reassignments and retraining were also used. In some cases, employees quit rather than change with the organization. For example, at Company B, 25% of the engineers joined other companies. Although not the only reason, some engineers were unhappy with the new engineering-manufacturing-marketing teams approach to new products and processes. At this time the job market for engineers was very good.

A common characteristic that was evident at all companies was empowerment of the worker (Zuboff, 1988). Networked computer systems gave each employee specific information for operating control (Rockart & Short, 1991) and improved communication. They were empowered to halt production when quality problems were encountered, contact suppliers directly regarding quality problems with purchased parts, and, through electronic mail, to communicate with all levels of management. In addition, management control was enhanced due to the ability to more accurately plan and control purchasing, production scheduling, quality, inventory levels, distribution, and delivery. Budgeting was easier. From an organizational control perspective, each company attempted to flatten the organization structure and reporting levels. In Company B, there were only three organization levels from the line worker to the plant manager.

For tracking purchased material, production, and inventory, bar coding was widely used. Employees logged onto specific workstations or production processes by passing an electronic wan over their coded badge. At log on, the computer screen showed the work to be performed. Planning and scheduling work was vastly improved. In addition, companies were able to build databases of manufactured goods consisting of design data, suppliers of parts, specific workers, dates, and times. At any point, they could find a specific customer's order and determine its stage of completion and estimate shipment times and delivery schedules. Company B used their database of all manufactured output to track quality problems on computers failing several years after manufacture. Certain design or part failures could then be corrected in other computers.

One major area for turnaround was quality. Each company was able to improve quality. Company B used three categories of quality: assembly, functional, and customer. As reported in Exhibit 5, the highest improvements were in their assembly and functional areas. Company C's improvement of quality was the primary reason for extending the warranty period from 2 to 5 years. This was a strategic marketing decision that competitors did not match.

Global competitive pressure to shorten the time from product design to delivery to the customer was strong. Using CAD\CAM and other computer software, all companies improved as measured by manufacturing cycle time. Company A also used a measure of manufacturing cycle efficiency. This was defined as the "total value added hours" divided by the "actual cycle hours." The measure for 1990 was as follows:

$$\text{Manufacturing Cycle Efficiency} = \frac{\text{Value Added Hours}}{\text{Actual Cycle Hours}} = 35\%$$

According to this company the range of manufacturing cycle efficiency averages 15-20% for U.S. companies and 80-85% for Japanese companies. While Company A is doing better than the domestic average, it needs significant improvement to match the Japanese average. Company A also reduced product development and engineering cycle times significantly. The latter had been a major bottleneck.

As to another critical success factor, customer responsiveness, management at each company stated that they were doing much better. However, Company A did not assess the product delivery time to the customer since their manufactured goods were usually part of a larger computer system. Company B was a job shop type of manufacturer that responded to customized orders. Machine setups and routing through different manufacturing processes were critical problems in the production process. Company B was able to significantly shorten machine setup time and manufacturing cycle time. Company C changed to a demand-pull production strategy. Upon receipt of customer orders, the MIS scheduled production, used EDI to order parts from suppliers, and prepared shipment times and billing data. This company eliminated work-in-process inventory and has insignificant finished goods on hand. In addition, Company C vastly improved its on-time shipments.

Accounting systems remained the same at the larger companies. Company C changed their system to trace only raw material as product cost while labor and overhead are fixed and allocated only at year end. The non-financial measures of performance received more attention in strategic planning, management control, and operational control. Management justified the cost of the changes by pointing to the reductions in personnel and physical resources and improvement in communication, manufacturing cycles, quality, employee morale, and delivery time. While these benefits are impossible to quantify, managers believe that the changes were necessary for survival of operations.

Conclusions

Under severe stress, each organization's operating managers utilized new technology and systems for planning and controlling operations. Timely and accurate information was critical to the success. There was a new awareness of the strategic implications of information technology at these companies. Understanding the value chain of the manufacturing process was an important part of the managers' concerns even though it was not explicit (Porter & Millar, 1985). Certainly, elimination of non-value added activities was key to improvements in cycle times and costs. Understanding the impact of the design and engineering phases on downstream activities was a dramatic discovery. Information at these early stages of the value chain helps decision makers anticipate questions of manufacturability, functionality, serviceability, and quality. The latter is critical as focus on the customer is key to Total Quality Management.

Each company developed an information system that fit the technological improvements and organizational changes. As revealed by the achievements, a large quantity of information consisted of non-financial measures. Key information items were defect rates, cycle times, order lead times, on time delivery, as well as progress in cost reduction programs.

The management information system in these companies changed to focus on the critical success factors for long term organization survival and growth. The measures of performance capture the richness of the technological improvements and the impact they have on organization objectives. In early 1991, the recession placed more competitive pressure on these organizations. Each survives today, but, if the changes discussed above had not taken place, it is unlikely that they would exist.

Exhibit 1

List of New Technology

FMS	Flexible Manufacturing Systems
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
ROBOTICS	
AGV	Automated Guided Vehicle
AI	Artificial Intelligence (Expert Systems)
CIM	Computer Integrated Manufacturing
JIT	Just-In-Time (Kanban)
TQM	Total Quality Management
SPC	Statistical Process Control
LAN	Local Area Network
WAN	Wide Area Network
EDI	Electronic Data Interchange

Exhibit 2

Operating Data for Company A

Worldwide Development and Domestic Manufacturing of
High Capacity Data Storage Products

Employees: 9,000; 350 Reassignments Per Month

Facilities: 5 Million Square Feet

Production: 100,000 Annual Volume; 8 Product Classes

152 Production Suppliers; At Least 3 Sources

20,000 Purchase Orders; $210 Million Annual Commitment

31,000 Active Part Numbers

High Engineering Change Activity:

- 1,000 Tooling Per Year
- 1,200 Product Per Year

Exhibit 3

Operating Data for Company B

Printed Circuit Board Assembly and Test Supply Plant

High Volume Manufacturer; Many Different Products To Fit Customer System

Many Different Manufacturing Routes And Different Cycle Times

Board Assembly: Lot Oriented; Board Test: Unit Oriented

Employees: 1,000

Exhibit 4

Operating Data for Company C

$20 Million Sales

400 Product Lines

Unlimited System Level Combinations: Very Low Unit Volume by Type

25% Test Failure Rate; Previous Attempts at Improvement Failed

Half Of Incoming Printed Circuit Boards Rejected

Seeking to Expand and Add Floor Space for Operations

Exhibit 5

Comparison of Results for Three Companies

Attribute	Company A	Company B	Company C
Manufacturing Cycle Time	30% Less	95% Less	90% Less
Raw Material Inventory		50% More	
Number of Suppliers	60% Less		
Work-In-Process Inventory	40% Less	80% Less	100% Less
Finished Goods Inventory			98% Less
Overhead Costs	6% Less		
Physical Space	54% Less		50% Less
Quality	3% Higher		
Assemble		29% Higher	
Functional		21% Higher	
Customer		10% Higher	
Initial Turn On			21% Higher
Warranty Period			2 to 5 Yrs
Product Development Cycle	50% Less		
Engineering Change Cycle	85% Less		
Machine Set Up		90 to 5 Min	
Personnel	15% Less		50% Less
On-Time Shipments			23% Higher

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